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## THE STORY SO FAR

Ken Tapping, 9<sup>th</sup> September, 2015

Outlining the history of the universe is definitely a work in progress. Where we are now is the result of centuries of work by scientists all over the world. Although we have we have much more to learn and it is doubtful that we will ever know the whole story, it really is surprising how much we have managed to find out. Here is the story so far.

Just under 14 billion years ago something made a little rip or tweak in the fabric of space-time. It gave rise to a little isolated bubble of space-time, very small – about the size of a single atom, extremely hot and incredibly dense. This then started to expand extremely quickly, soon reaching the size of a grapefruit. This event is often referred to as the Big Bang. A millionth of a second after the beginning (AB) the temperature had fallen enough for protons and neutrons to form, joining electrons that were already present. However, it was still too hot for them to condense into atoms.

Roughly 3 minutes AB the temperature had fallen to about 100 million degrees Celsius, still too hot for atoms to form. If we were there to look around we would be surrounded by a very hot, utterly featureless, glowing fog. The expansion and cooling continued, so that about 300,000 years AB the temperature had fallen to about 10,000 degrees and the protons, neutrons and electrons started to combine to form the first atoms. Because hydrogen and helium are stable at such temperatures, they were the first elements to form. The fog started to clear. By 380,000 years AB the fog was gone and for the first time everything became clear to see. However, there was not much to see other than some faint irregularities that were denser and cooler than their surroundings. These would eventually become the embryos of the first stars and galaxies. This is the youngest phase of the universe we can observe. We see it as the “cosmic microwave background”, and the embryo stars and galaxies as small changes in its temperature. Once started, these “embryos” became denser and grew rapidly.

By about a billion years AB galaxy and star formation were proceeding at a rapid rate, fuelled by the collapse of great clouds of hydrogen and helium. However, since they were the only elements present at that time, planets could not form and life as we know it could not begin.

Stars produce energy by turning hydrogen into the other elements. All the oxygen, carbon, nitrogen, silicon and other elements making up the planets and us were formed as waste products from energy production in young stars. Those early stars were big, bright and did not live long, ending their lives in huge explosions, ejecting their waste products into space, providing the ingredients for the formation of planets and life.

As billions of years passed, the elements in those clouds reacted with one another, producing many of the chemicals needed for life as we know it. If we could go back to see the universe as it was then, it would look quite familiar to us. About 9.5 billion years AB, some 4.5 billion years ago, a cloud collapsed to form a new star – the Sun, along with its planets and other objects. One of the new planets was the Earth. At 10.5 billion years AB (3.5 billion years ago), life had appeared on the Earth. It is likely that this process was taking place at countless other places across the universe. Initially, Earthly life developed very slowly, until about 13.4 billion years AB, 500 million years ago, that life suddenly exploded, and we were on course for the world we see around us today.

Saturn lies low in the southwest in the evening. Venus and Mars lie low in the predawn sky, Jupiter lies deeper in the dawn glow and is hard to find. The Moon will be New on the 12<sup>th</sup>. If it is clear and dark you might be able to see a glow resembling a diffuse, starless “Milky Way” in the east before dawn. This is the zodiacal light – sunlight scattering on dust particles that have so far not become part of planets.

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